

**St. Louis Ordnance Plant, Hanley Area  
Remedial Investigation Phase I  
Technical Memorandum Discussion Meeting  
Kansas City District Emergency Management  
Conference Room  
1<sup>st</sup> Floor-Room 164  
Bolling Federal Building  
Agenda**

**30 June 2005**

- 1015-1020 Introductions (Josephine Newton-Lund)
- 1020-1025 Meeting Objectives (Josephine Newton-Lund)
- 1025-1100 Summary of Previous Environmental Work and Overview of Corps of Engineers Field Work Performed December 2004-February 2005 (Francis Zigmund and Brad Brink)
- 1100-1115 Site Conceptual Model Review (Debby Snodgrass)
- 1115-1200 Data Evaluation of Sediment/Water and Soils (Kansas City District Project Team)
- 1200-1245 Lunch
- 1245-1315 Overview of Groundwater Flow and Data Evaluation of Groundwater (Kansas City District Project Team)
- 1315-1400 Contaminant Summary (Kansas City District Project Team)
- 1400-1430 Path Forward Towards RI/FS Completion (Bob Sevcik)
- 1430-1500 Open Discussion

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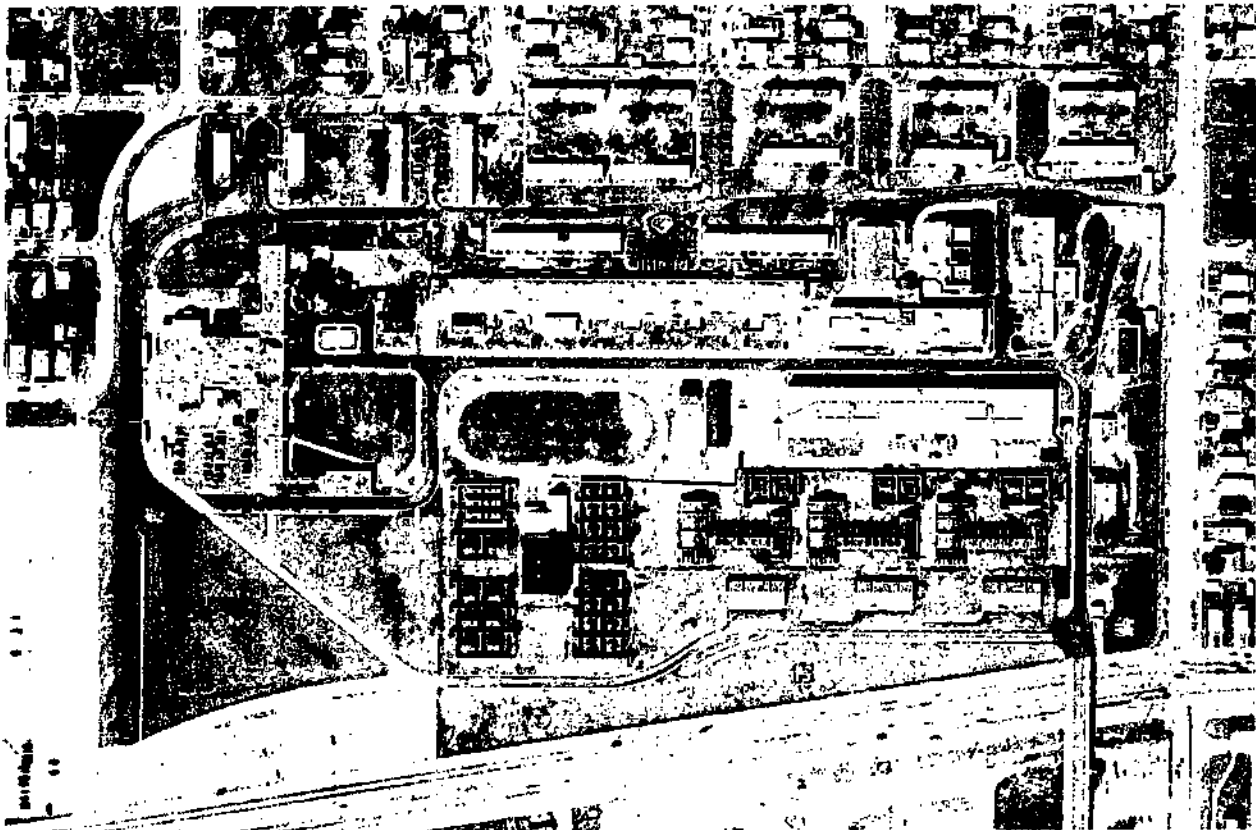


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**Technical Memorandum-Final**  
**Hanley Area Phase I Remedial Investigation**  
**Former St. Louis Ordnance Plant (SLOP)**  
**St. Louis, Missouri**



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**For the**

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**May 2005**

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### List of Acronyms

ACMs	Asbestos Containing Materials
ASTM	American Society for Testing and Materials
DQOs	Data Quality Objective
DO	Dissolved Oxygen
DOD	Department of Defense
Ft-bgs	Feet below ground surface
Ind-PRG	Industrial Soil Preliminary Remediation Goal
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
MCLs	Maximum Contaminant Levels
MDNR	Missouri Department of Natural Resources
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NASA	National Aeronautics and Space Administration
NTUs	Nephelometric Turbidity Units
OD	Outside Diameter
ORP	Oxidation Reduction Potential
PA/SI	Preliminary Assessment/Site Inspection
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PETN	Pentaerythritol Tetranitrate
PRGs	Preliminary Remediation Goals
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
Res-PRG	Residential Soil Preliminary Remediation Goal
RI	Remedial Investigation
RRC	Regional Readiness Command
SAP	Sampling and Analysis Plan
SLAAP	St. Louis Army Ammunition Plant
SLOP	St. Louis Ordnance Plant
SVOCs	Semi-Volatile Organic Compounds
S-GW	Soil to Groundwater Leaching Protection
TAL	Target Analyte List
TOC	Total Organic Carbon
USACE	United States Army Corps of Engineers
USACE-KCD	United States Army Corps of Engineers, Kansas City District
USATHAMA	United States Army Toxic and Hazardous Materials Agency
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

## **1.0 INTRODUCTION**

### **1.1 PURPOSE**

This Technical Memorandum serves to present the results of the Phase I Remedial Investigation (RI) at the Hanley Area of the former St. Louis Ordnance Plant (SLOP) and to evaluate the data against risk-based screening criteria. The primary purpose of this investigation was to address data gaps identified from previous Army investigations and to reduce uncertainties for a follow-on contractor to resume environmental work. Thus, this memorandum is intended to serve as a tool for project management decisions about further investigation and/or remediation.

The objectives of this remedial investigation are defined by the following data quality objectives (DQOs). These included: further definition of the nature and extent of contamination, both horizontally and vertical; determination of potential source(s) of contamination; meeting the precision, accuracy, representativeness, completeness, and comparability criteria for the data; obtaining data of sufficient quality to support risk assessment; and for the determination of future remediation activities, if required.

The field investigation of the Phase I RI was conducted from December 2004 through February 2005. Procedures utilized for the acquisition of data of known and sufficient quality to support these project DQOs are found in the Final Phase I Remedial Investigation Work Plan (United States Army Corps of Engineers (USACE), 2005).

### **1.2 SITE LOCATION AND HISTORY**

The Hanley Area of the former St. Louis Ordnance Plant is located on the western boundary of the city limits of St. Louis, Missouri and adjacent to St. Louis County. The facility lies approximately three miles west of the Mississippi River and 0.25 miles south of the intersection of Interstate 70 and Goodfellow Boulevard. A general site map is provided as Figure 1-1.

From 1941 to 1945, the former St. Louis Ordnance Plant was solely operated as a small arms ammunition production facility. The primary products of the ordnance plant were 30 and 50-caliber ammunition. The overall plant was divided into two areas designated Plant Area No. 1, east of Goodfellow Avenue, and Plant Area No. 2, west of Goodfellow Avenue. Much of Plant Area No. 1 was utilized for the metal forming process (casings and projectiles), loading of final product, packing and shipping. There was a primer and incendiary component manufacturing facility on the southern end of Plant Area No. 1. Plant Area No. 2 solely produced the primer and tracers components used in the assembly of the final product. These processes include the blending of primary explosives, incendiary compounds and the tracer charging of 30 and 50-caliber projectiles.

Per the United States Army Toxic and Hazardous Materials Agency (USATHAMA) Final Report DRXTH-FS-TR-81105, June 1981, during the time frame from 1945 to 1959, including the Korean War, some buildings within Area No. 2 of the original St. Louis Ordnance Plant were

used by the United States Army Adjutant General's Office for maintaining service records and the Department of Defense (DOD) Finance Center for classrooms. The report also indicated that the facility was being upgraded for additional small arms manufacturing capabilities (i.e. 20 mm reported in the Archive Search Report, Former St. Louis Ordnance Plant, dated December 1993). Machinery was installed, but the plant never commenced or resumed production during the Korean War Era. After the Korean Conflict, the machinery was removed, transferred to other facilities or declared excess and disposal effected.

In 1959, Hanley Industries, Inc. (a subsidiary of KDI Precision Products) leased 14.68 acres of the 27.68 acre Plant Area No. 2 of the former St. Louis Ordnance Plant. Hanley conducted operations on the 14 plus acres from 1959 to 1979. During their tenure, Hanley produced specialized devices for both the United States Military and the National Aeronautics and Space Administration (NASA).

Per the USATHAMA Report, the Goodfellow United States Army Reserve Center was established on the remaining 13 acres in the early 1960s. At the time of the transfer, much of the 13 acres still contained the buildings, magazines and bunkers that were part of the primer manufacturing area of Plant No. 2.

The Goodfellow United States Army Reserve Center transferred some of the 13 acres to the United States Department of Labor, which is now being utilized as a Job Corps training center. Some of the original primer manufacturing buildings and bunkered areas have been removed. Other buildings such as 223A, the former tracer charging operation (also labeled on more recent maps as 223C), has been renovated and is being used as a Job Corps dormitory. For a more complete history of the Former St. Louis Ordnance Plant, please refer to the historical information contained in **Appendix A**.

The Sverdrup U.S. Army Reserve Center (formerly the Goodfellow U.S. Army Reserve Center) is currently occupied by the 89<sup>th</sup> Regional Readiness Command (RRC). A contractor for the 89<sup>th</sup> RRC has removed asbestos from all of the Hanley Area buildings and subsurface structures, and has demolished some of the buildings. The 89<sup>th</sup> RRC plans to demolish all of the buildings on-site as funding becomes available.

### **1.3 SITE DESCRIPTION**

The Hanley Area of the former St. Louis Ordnance Plant is located on a relatively flat terrace covering most of the 14.68 acres, and includes a steep slope down to Goodfellow Boulevard along the East side. A series of warehouse buildings, bunkers, and related buildings are located on the flat portion. The site contains a number of underground rooms, tunnels for service utilities, an underground wastewater collection system, and a storm water collection system. A paved service road runs south-north along the east side of Buildings 219G, 219D, and 219A.

All of the buildings present in the Hanley Area were stripped of equipment and this work, together with lack of maintenance, has left warehouse Buildings 219A, 219D, 219G, and the frame buildings located inside the concrete-walled explosive containment bunkers in a state of poor repair.



However, massive concrete walls of the bunkers appear to be in relatively good condition. Buildings 218A, 218B, and 218C were demolished by an 89<sup>th</sup> RRC contractor during the summer of 2004. Building 219B was demolished in 2005.

Underground tunnels are constructed of reinforced concrete with approximate interior cross-sectional dimensions of 8 ft. wide x 8 ft. high, and connect to the basements of most of the buildings within the Hanley Area. The horizontal tunnels change elevation at abrupt intervals, as required, to maintain an elevation of 10-12 feet below the topographic surface. A stair-cased entrance or vent to the surface and a sump-like low area occurs at each point where the tunnel elevation changes. One vent allowing access to the entire tunnel system is located off site along the east side of Goodfellow Boulevard. The tunnels have been blocked off between the Hanley Area and the area occupied by the Job Corps Center. Other tunnel entrances exist in the basements of several buildings within the area.

\* \* \*

## 2.0 PREVIOUS ENVIRONMENTAL WORK

The following sections provide an overview of the numerous environmental investigations conducted by the 89<sup>th</sup> RRC at the former SLOP site. Sampling locations for historical and Phase I RI investigations are presented in **Figure 2-1**. Analytical data summaries for historical and Phase I RI data are presented and discussed in Section 5.

### 2.1 USATHAMA-BATTELLE COLUMBUS LABORATORIES (1981)

Battelle Columbus Laboratories investigated the Hanley Area in 1980. The investigation consisted primarily of wipe samples of building surfaces and waste handling system components, analyzed for explosives and metal residues. A limited number of sediment and surface water samples were collected for similar analyses. The results are briefly summarized:

- Heavy metal residues were found on all building and magazine interior surfaces and in the discharge of the sewers. Heavy metal concentrations ranged from below detectable limits to 24, 147, 32, and 102 ug/m<sup>2</sup> for silver, nickel, mercury, and cadmium, respectively. ~~The highest lead concentration identified during the survey was found in 219E (36,440-ug/m<sup>2</sup>).~~
- Explosive residues were found on the walls in buildings 218A, 218B, 218C, and 220 and magazines 219C, 219H, 227J, 227M, 227O, 228C, and 228F.
- Explosives were also identified in powder wells adjacent to buildings 218A and 218B. Detected explosives included Tetryl, Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), and Pentaerythritol tetranitrite (PETN).
- No explosives were detected in the sewer system discharge.

### 2.2 USATHAMA-ICF TECHNOLOGIES, INC. (1991)

USATHAMA completed an environmental study in 1991. A screening survey was performed for contamination in environmental media and to determine the extent of asbestos containing materials (ACMs) within the tunnel system.

- Fifteen surface soil samples (0-1 ft bgs) were collected for metals analyses, of which three were considered background. Two of the 15 were analyzed for semi-volatile organic compounds (SVOCs).
- Thirteen shallow soil samples (1-2 ft bgs) were collected and analyzed for metals and six were analyzed for SVOCs. Three of thirteen samples were considered background.
- Two tunnel water samples were collected and analyzed for target analyte list (TAL) metals, explosives, and TCL organics.

- Three sewer sediment samples were collected for VOCs, explosives, and TAL metals analyses.
- Two sewer water samples were collected for VOCs, explosives, and TAL metals analyses.
- Six tunnel sediment samples were collected for explosives and TAL metals analyses.
- Two tunnel water samples were collected for VOCs, explosives, and TAL metals analyses.
- Sixteen temporary piezometers were installed to collect groundwater samples for chemical analysis and obtain water level measurements. Due to low groundwater recharge rate, some analytes could not be collected at each temporary piezometer. Nine temporary piezometers were sampled and analyzed for VOCs, explosives, and TAL metals; two for VOCs, explosives, TAL metals, and OA-2; one for VOCs and TAL metals; and one for VOCs. Three temporary piezometers did not recharge sufficiently to collect groundwater samples.
- Five monitoring wells were installed and sampled for VOCs, explosives, and TAL metals analyses.

The assessment report confirmed the presence of metals and SVOCs in the surface and subsurface (1-2 ft bgs) soils. Sediment and surface water in powder wells contained metals and explosives. The assessment also identified carbon tetrachloride in an on-site monitoring well (MW105), in addition to VOCs in the up gradient monitoring well (MW101).

## **2.5 SHAW ENVIRONMENTAL (2003)**

In 2003, Shaw Environmental conducted a Limited Phase II Environmental Site Assessment as a result of the off-site up gradient contamination found by TapanAm.

- Four direct push soil samples were collected at depth in the vicinity of MW101 to assess VOC contamination. Analytical results indicated that soils were not impacted by VOCs.
- The four geoprobe borings were converted into temporary monitoring wells and groundwater was sampled and analyzed. Although several VOCs were present above detection limits, none exceeded maximum contaminant levels (MCLs).

## **2.6 SCS ENGINEERS (2004)**

In 2004, SCS Engineers were hired by the 89<sup>th</sup> RRC to conduct sampling and analyses of building materials, perform asbestos abatement of buildings and subsequent demolition of buildings at the former Hanley area.

Based on field screening results, a total of 20 sediment samples and 19 samples of various types of building materials were collected for laboratory analysis. One water sample and 20 wipe samples were also collected for laboratory analysis.

The report concluded that, while not impacted with elevated metals, samples taken from the buildings did appear to have the highest concentrations of explosives compounds found during the sampling event. Sediments throughout the complex contained elevated levels of metals, as did the one tunnel water sample taken.

## **2.7 USACE-KCD (2005)**

USACE-KCD was tasked by USAEC in 2004 with compiling the environmental data collected from previous investigations at SLOP and conducting a preliminary evaluation of that data to determine its completeness for preparing an RI report. The evaluation included identifying potential data gaps based on the distributions of plotted data and the results of a risk-based screening and comparison to background. A preliminary conceptual site model was developed to facilitate this effort and is described in Section 2.7.1. Another task completed by USACE-KCD was establishment of an information repository, which is described in Section 2.7.2.

Meetings were held with all stakeholders throughout the process for review and input and, in January 2005, an RI work plan (USACE-KCD, 2005) was finalized. The field investigation began in December 2004 and concluded in February 2005. The investigation was termed Phase I to acknowledge the possibility that the newly collected data may reveal additional gaps for a follow-on contractor to address in another investigative phase. Section 3 of this technical memorandum provides a summary of the Phase I RI field activities completed by USACE-KCD.

### **2.7.1 Preliminary Conceptual Site Model**

The project conceptual site model (CSM) describes the overall environmental system where contamination has occurred and the processes that determine the transport from a source through environmental media to human and/or ecological receptors. The CSM, developed during the field investigation design, has the following components:

Primary Source – Releases related to operations, such as spills, burning, and leaks

Primary Media – Surface soil, sediments and surface water

Release Mechanisms – Overflow, infiltration, runoff, air advection

Affected Media – Soil, groundwater, sediment, surface water, air

Exposure Routes – Ingestion, inhalation, dermal contact

Receptor Groups – Workers, site visitors, trespassers, residents

For an exposure pathway to be complete, contamination must be able to reach a receptor. The components of a completed pathway include a contaminant source, a mechanism for chemical release, intermediate transport mechanisms, migration pathways, receptors, and exposure routes.

~~Results of the sampling indicated that surface soils were contaminated with lead at levels of potential concern. Water samples contained lead and explosives at levels of potential concern. The study recommended confirmatory sampling and asbestos abatement.~~

### **2.3 HARZA (1998)**

HARZA Environmental Services, Inc. completed a Site Investigation Report in 1998. The objective of the investigation was to determine the presence of volatile organic compounds (VOCs), explosives, and metals in site soils and sediments. Sampling consisted of the following:

- Eleven surface soil samples from 0-1 ft bgs were collected and analyzed for VOCs, SVOCs, explosives, and metals.
- Eight shallow soil samples from 1-2 ft bgs were collected and analyzed for VOCs, SVOCs, explosives, and metals.
- Two subsurface soil samples at 6-8 ft bgs and 16-18 ft bgs were collected for explosives and metals analyses.
- Two sewer sediment samples were collected and analyzed for explosives and metals.
- Two powder well samples were collected for explosives and metals analyses.

The study determined VOCs, SVOCs, metals, and Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and HMX present in site soils and sediments.

### **2.4 TAPANAM (2001)**

TapanAm Associates, Inc. completed a Draft Preliminary Assessment/Site Inspection (PA/SI) Report in 2001. The assessment evaluated the extent of surface soil contamination and the potential for contaminant migration by surface routes through underground utility tunnels. The potential for groundwater contamination was also evaluated. Environmental sampling consisted of the following:

- Forty-two surface soil samples from 0 to 1 ft bgs were collected for explosives and TAL metals analyses; some samples were composites. Of the 42 samples, three were collected off site for evaluation of background metals. Thirteen surface soil samples were collected for VOCs analysis.
- Three subsurface soil samples were collected near sewer line breaks and two near PW12 and PW13 and submitted for VOCs, explosives, and TAL metals analyses.
- Seventeen powder well sediment samples were collected for VOCs, explosives, and TAL metals analyses.

If all components of an exposure pathway are not present, then the pathway is incomplete and exposure and subsequent risk do not occur. For human health, it was determined that current receptors to the site are occasional visitors and those in a working capacity. Because of the land use zoning, there is a possibility that future use may include residential. Completed pathways for ecological receptors were assumed to be insignificant, if they exist at all, because of the limited habitat at the site. Therefore, further ecological evaluation was determined to be unwarranted. Exhibit 2-1 is a visual depiction of the preliminary conceptual site model.

### **2.7.2 Information Repository**

Additionally, prior to the initiation of field investigation activities, USACE-KCD established an information repository in accordance with 40 CFR 300.805(a). This repository is located at the St. Louis Central Public Library. An information repository contains up to date documents reflecting on-going environmental restoration activities. Project documents currently included in the repository are as follows:

- Investigation Report, USATHAMA-Battelle Columbus Laboratories dated June 1981
- St. Louis Ordnance Plant Environmental Study Status Report, USATHAMA dated November 1991
- Site Investigation Report, Harza Environmental Services dated December 1998
- Preliminary Assessment/Site Investigation Report, TapanAm Associates, Inc. dated June 2001
- Limited Phase II Environmental Site Assessment Report for the Investigation of Impacted Groundwater, Shaw Environmental, Inc. dated March 20, 2003
- Phase I Remedial Investigation Work Plan, U.S. Army Corps of Engineers, Kansas City District, dated January 2005
- Notice of Availability, Published on January 20, 2005 in the St. Louis American Newspaper
- Technical Memorandum, U.S. Army Corps of Engineers, Kansas City District, dated May 2005.

The aforementioned project documents currently form the basis of the Administrative Record file. The Administrative Record file includes relevant documents that are relied upon in selecting the response action at this site. A copy of the Public Notice of Availability is provided in **Appendix B**.

\* \* \*

### 3.0 FIELD INVESTIGATION SUMMARY

Field investigations by USACE-KCD as part of this Phase I RI included the collection of 15 composite surface soil samples, 22 discrete surface soil samples, 37 subsurface chemical samples, six subsurface geotechnical samples, six groundwater samples, and installation and development of one monitoring well.

Field, Quality Control (QC), and matrix spike/matrix spike duplicate (MS/MSD) samples were submitted to Analytical Management Laboratory (AML) in Olathe, Kansas; Quality Assurance (QA) samples were submitted to Severn Trent in Earth City, Missouri; and geotechnical samples were submitted to Shannon & Wilson, Inc. in St. Louis, Missouri.

#### 3.1 COMPOSITE SURFACE SOIL SAMPLING

Fourteen composite surface soil samples, each consisting of five grab samples of equal volume, were collected from 0 to 1 foot on 15 December and 16 December 2004. One composite soil sample (SLOP-CSS-015) consisted of three grab samples due to limited space for sampling. Three split samples were collected by the Missouri Department of Natural Resources (MDNR) at composite locations SLOP-CSS-009, SLOP-CSS-010, and SLOP-CSS-012. Compositing samples were collected using a stainless steel hand auger. Samples from each location were submitted for metals analysis. Samples from nine locations were submitted for PAH analysis. Composite sampling locations are presented on **Figure 3-1**. Composite soil sample identification numbers, depths, and analysis are presented in **Table 3-1**.

#### 3.2 DISCRETE SOIL SAMPLING

Discrete soil samples were collected from 22 of 23 proposed soil boring locations 18 January 2005 through 23 January 2005. Each boring was continuously sampled for logging purposes. Boring logs are presented in **Appendix C**. One proposed boring, SLOP-SB-004 was inaccessible and was not sampled. Soil samples were collected from most borings utilizing a 6610 DT Geoprobe rig equipped with a 2-inch macro core sampler and clear polyvinyl chloride (PVC) sleeve. However, boring SLOP-SB-007, located within the north-south tunnel was sampled through an opening in the concrete slab using a stainless steel hand auger. Samples from monitoring well boring SLOP-SB-023 (GW-MW106) were collected using a CME 550 rotary drill rig equipped with nominal 8-inch outside diameter (OD) hollow-stem augers and stainless steel split spoons. Discrete soil sampling locations are presented on **Figure 3-1**. Soil sample identification numbers, depths, and analysis are presented in **Table 3-1**.

##### 3.2.1 Surface Soil

Seventeen discrete surface soil samples were collected from 0 to 1 foot from soil boring locations and analyzed for PAHs and metals. Two discrete surface soil samples were collected from 0.5 to 1.0 feet bgs for total organic carbon (TOC) and soil pH analyses. An additional three locations were sampled for Polychlorinated Biphenyls (PCBs) only.

### 3.2.2 Subsurface Soil

Subsurface soil samples were collected from 22 soil borings placed adjacent to powder wells, sewer lines, and foundations. Samples were collected from 3 to 4 feet bgs at 12 locations and immediately below the powder wells, sewer lines and foundations at each of the 22 locations. The depth to the base of powder wells, sewer lines and foundations at each sampling location was verified in the field using a weighted or wooden tape.

Samples collected from 3 to 4 feet were analyzed for Polycyclic Aromatic Hydrocarbons (PAHs) and metals. Samples collected immediately below the bottom of powder wells, sewer lines, and foundations were analyzed for VOCs, metals, and explosives. VOC samples were collected from the bottom of the sampling interval using the EasyDraw® syringe method. Two discrete soil samples were also collected from 11.0 to 11.5 feet bgs for TOC and soil pH analyses. Three split samples were collected by MDNR from 6.0 to 7.0 feet bgs at SLOP-SB-001, SLOP-SB-002, and SLOP-SB-013 and one split sample was collected from 15 to 16 feet bgs at SLOP-SB-021.

### 3.2.3 Geotechnical Samples

Geotechnical soil samples for moisture content (American Society for Testing and Materials (ASTM) D2216) and sieve analysis (ASTM D422) were collected from direct push soil boring SLOP-SB-001 at 5 to 8 feet bgs and 15 to 18 feet bgs, SLOP-SB-009 at 5 to 8 feet bgs, and SLOP-SB-016 at 15 to 18 feet bgs. Additionally, geotechnical soil samples were collected during the installation of monitoring well SLOP-MW-106 from 0.5 to 2.5 feet bgs and 16 to 18 feet bgs for moisture content (ASTM) D2216, bulk density (ASTM D2937), and sieve analysis (ASTM D422). Samples from the monitoring well boring were collected using a thin-walled tube in accordance with ASTM D1587. Thin-walled tubes were capped and taped in the field and samples extruded at the laboratory. Geotechnical samples for shallow soil and subsurface soil are presented in **Table 3-1**.

## 3.3 Monitoring Well Installation and Development

Monitoring well installation was conducted from 19 January 2005 through 22 January 2005. One monitoring well (MW-106) was installed hydraulically downgradient of Building 220 to fill a data gap in an area of the site that has not been previously investigated. The location of monitoring well MW106 is presented on **Figure 3-1**. The borehole for monitoring well installation was advanced to 36 feet bgs using nominal eight inch outside diameter hollow-stem augers and continuously sampled for logging purposes. The monitoring well boring log is presented in **Appendix D**.

Monitoring well MW-106 was installed consistent with the five existing on-site monitoring wells. The well was constructed using 2-inch diameter threaded flush joint schedule 40 PVC riser pipe and 20 feet of 0.010-inch slotted screen. The screened interval was installed from 15 to 35 feet bgs. Clean, inert, 10/20 silica sand was placed by tremie pipe and extended from the bottom of the borehole to three feet above the top of the well screen. A seal five foot thick, consisting of bentonite pellets, was placed in the annular space above the top of the filter pack. The bentonite seal was allowed to hydrate a minimum of 12 hours before installing a grout seal.



Cement-bentonite grout, consisting of Portland cement, water, and five percent bentonite was placed by side discharge tremie pipe above the bentonite seal to within three feet of ground surface. The grout was allowed to set for a minimum of 48 hours before any additional work resumed on the well. All depths were verified during installation by measurement with a weighted tape.

The well completion consisted of a flushmount cover embedded in a 12-inch circular well pad extending from three feet bgs to ground surface. A survey marker was permanently embedded in the pad. A lockable j-plug was placed in the top of the pvc well riser and an aluminum tag containing the monitoring well number was placed on the lock. Existing wells and the newly installed well were keyed alike. A well construction drawing is provided in **Appendix D**.

The newly installed monitoring well was developed on 22 January 2005 after the grout was allowed to set a minimum of 48 hours. Development consisted of initially surging the screened interval of the well with the bladder pump as the pump was lowered into the well. The well was then pumped until turbidity was below 50 nephelometric turbidity units (NTUs) and all parameters had stabilized. Water temperature, dissolved oxygen (DO), specific conductance, pH, oxidation reduction potential (ORP), and turbidity were measured and recorded on a well development form (**Appendix D**) during development. Approximately 3.5 times the well volume (a total of 14.7 gallons) was removed during development with a final turbidity reading of 3.7 NTUs.

### 3.4 GROUNDWATER SAMPLING

Groundwater sampling was conducted 1 February 2005 and 2 February 2005. Groundwater samples were collected at five existing wells and one newly installed well for VOCs, metals, and explosives (**Figure 3-1**). Groundwater sample identification numbers and analysis are presented in **Table 3-2**. Prior to sampling, a synoptic round of water levels was collected and recorded in the field logbook. Water levels were also measured before and during purging at an individual well and recorded on a well purge form. All water levels were measured from the permanent mark on the top of the well casing.

Wells were purged and sampled using Low-Flow procedures. Purging was conducted with a portable, stainless steel QED Sample Pro bladder pump equipped with a Teflon bladder and Teflon-lined polyethylene tubing. Measurement of water quality parameters (i.e., well stabilization parameters) during well purging was accomplished with a YSI 600 XL Water Quality Meter capable of measuring water temperature, DO, specific conductance, pH, and ORP through a flow-through cell. Turbidity was measured separately on a LaMotte 2020 turbidimeter. Water quality parameters were monitored continuously during purging and values recorded on a well purge form every 5 minutes. Monitoring well purge forms are presented in **Appendix E**.

### 3.5 SURVEYING

Woolpert, Inc. of Fairview Heights, Illinois surveyed each soil sampling location as well as the newly installed monitoring well (MW-106) and existing monitoring wells (MW-101 through

MW-105). Each soil sampling location was marked using laths and labeled with a unique identification number prior to the survey crews arrival on site. A permanent benchmark (letter "L") was cut on top of the concrete base of a light pole near the south gate to provide elevation control. Ground surface elevations were established to the nearest 0.01 feet and referenced to the National American Vertical Datum of 1988. Elevations were provided for both the well pad and riser at monitoring well locations. Horizontal control locations were established to the nearest 0.1 feet and referenced to the Missouri East State Plane North American Datum of 1983. Survey data is presented in **Table 3-3**.

\* \* \*

## **4.0 PHYSICAL SETTING**

### **4.1 PHYSIOGRAPHY AND TOPOGRAPHY**

The site is located on the northwestern flank of the Ozark Plateau in the Dissected Till Physiographic Province (Miller, 1974). Topography of the Dissected Till Plains Province is gently rolling with elevations from 500 to 700 feet above Mean Sea Level (MSL). Topographic slopes are local reflections of the very gentle regional dip of about 55 feet per mile to the northeast (Harrison, 1997).

### **4.2 GEOLOGY**

#### **4.2.1 Overburden Soils**

The soil matrix at the Hanley Area has been characterized and mapped as Urban land, upland, with 0 to 5 percent slopes (Soil Conservation Service, 1979). The Soil Conservation Service describes this classification as surfaces composed of greater than 85 percent manmade, impervious materials. Typically, these soils have been extensively reworked and reshaped. Construction activities at the facility leveled much of the site's original topography.

Immediately adjacent to the contour boundaries of the Urban Land map unit, in all directions, lies the Urban Land-Harvester Complex. Harvester soils consist of deep, moderately drained soils on uplands. These soils were formed in 12 to 40 inches of reworked loess fill material over truncated or buried loess soils. These soils have moderately slow permeability. This classification extends into areas where soil background samples were collected for the SLAAP study (URS, 2004).

Soils encountered at the site during the PA/SI are typically described as yellowish-brown silty clay fill material, with some concrete, red brick, ceramic, limestone gravel, and wood debris, to a depth of approximately 20 to 25 feet below ground surface (bgs). According to TapanAm (2001), the fill/native soil contact was difficult to determine since some of the fill material is reworked native material excavated from the open field adjacent to the south end of the site. Soil borings drilled during the PA/SI ranged in depth from 21 feet to 46 feet bgs.

Surface soil sampling activities conducted during the Phase I RI typically encountered brown silty clay soils with large amounts of concrete, limestone gravel, red brick, glass, asphalt, and clay tile. Similar materials were detected in soil borings with the amount of debris decreasing significantly below approximately 2 feet bgs. Similar to observations during the PA/SI investigation, the contact between the fill and native material was difficult to determine since the fill is reworked native material. Soil borings drilled during the Phase I RI ranged in depth from 3.4 feet to 36 feet bgs.

#### **4.2.2 Bedrock**

Early Pennsylvanian age rocks of the Marmaton and Cherokee Groups make up the bedrock beneath the site and are thought to be approximately 100 feet thick (USATHAMA, 1991). The St. Louis area has a monocline structure that gently dips to the northeast. The structural attitude of the beds results from the compressional, tensional, and uplifting forces, which created a series

of faults and fractures evidenced by the anticlinal, synclinal, and fault zone structures located in the area. The SLOP site is located approximately 1.5 miles east of the Cheltenham Syncline on the downwarped eastern limb and approximately two and a half miles and five miles west of the Florissant Dome and the St. Louis fault zone, respectively.

As previously stated early Pennsylvanian-age rocks of the Marmaton and Cherokee Groups make up the uppermost Pennsylvanian bedrock strata beneath the Hanley area. These Pennsylvanian units un-conformably overlie the Mississippian-age rocks of the St. Genevieve Limestone, which in turn un-conformably overlie the St. Louis Limestone (Harrison, 1997). It is anticipated that the bedrock strata beneath the site dips to the west-southwest, towards the axis of the Cheltenham Syncline. A generalized Stratigraphic column for the counties of St. Louis, St. Charles, and Jefferson is presented in **Figure 3-2**.

PA/SI direct push borings encountered weathered shale in DP-10 at 32.8 feet bgs on the northeastern corner of the site and weathered sandstone in DP-8 at 31.4 feet in the central portion of the site. Bedrock was encountered during hollow-stem auger drilling in the borings for monitoring wells MW-101 (weathered shale at 42.2 feet bgs) and MW-104 (chert gravel over a weathered shale at 43 feet bgs). The depth to the weathered bedrock surface decreases toward the north, which is consistent with the site topographic relief. Soil borings for discrete sampling and the monitoring well boring for MW106, drilled during the Phase I RI, were too shallow to encounter bedrock.

### **4.3 HYDROGEOLOGY**

#### **4.3.1 Overburden Aquifer**

The uppermost water-bearing zone at the SLOP site is within the clayey silt to silty clay fill and native soil underlying the site. The exact locations of the water-bearing zones during previous investigations were difficult to ascertain since the soils did not yield significant amounts of water. The determination of water-bearing zones recorded on boring logs were inferred from drilling information such as advancement rate during drilling and water on sampling rods. Previous direct push sampling across the site failed to consistently produce water. Most of the direct-push borings contained little water upon completion and exhibited very slow recharge with the exception of an upgradient piezometer and three temporary piezometers located at the base of the slope along Goodfellow Boulevard.

Groundwater was observed in monitoring well boring SLOP-SB-023 (MW-106) during this investigation at approximately 17.5 feet bgs. Groundwater was not observed in any of the other on-site soil borings. Groundwater elevation data collected on 1 February 2005 from the five existing wells and one newly installed well, indicate flow in the overburden to the east and northeast towards Goodfellow Boulevard under the influence of a hydraulic gradient ranging from 0.02 to 0.05 (**Figure 3-3**). The gradient and flow direction are both consistent with a previous investigation conducted by TapanAm (2001). Groundwater elevations ranged from 531.02 feet in MW-105 located northeast of Building 219A to 559.43 feet in background well MW-101 located in a field south of the site.

#### **4.3.2 Bedrock Aquifer**

The bedrock aquifers in the vicinity of the site receive recharge from precipitation falling directly on the area (Miller, 1974). The movement of water from the ground surface soil and subsurface soil into the bedrock takes place primarily along fractures and solution openings in the rock. Bedrock aquifers are divided into five groups as follows:

- Post-Maquoketa includes all bedrock above the Maquoketa Shale, which probably acts as a confining bed in the St. Louis area (Miller, 1974);
- Kimmswick-Joachim includes all aquifers between the base of the Maquoketa Formation and the base of the Joachim Formation and is not considered a good aquifer due to insufficient well yields;
- St. Peter-Everton includes the St. Peter Sandstone and the Everton Formation;
- Powell-Gasconade includes all units in the Canadian Series of Early Ordovician age; and
- Eminence-Lamotte includes all units below the base of the Gasconade Dolomite.

#### **4.4 SURFACE WATER**

No surface streams or ponds exist on the site. More than 60 percent of the ground surface at the former SLOP is covered by asphalt, concrete, buildings or other impervious materials (USACE Archives Search Report, 1993). The rest of the ground surface is covered with grass and native vegetation. Surface runoff from the site enters the city storm drainage system.

#### **4.5 LAND AND WATER USE**

The property is located in an urban, mixed-use (commercial, industrial, and residential) neighborhood near Interstate 70 in St. Louis, Missouri. According to a City of St. Louis zoning specialist, there are two types of zoning that apply to the site: 1) 26.40 -Neighborhood Commercial District; and 2) 26.20 – Single-Family Dwelling District. The latter encompasses the largest portion of the site, although there are no existing residences on the property.

Bedrock units in and around St. Louis are capable of yielding varying amounts of groundwater. Well yield depends on site-specific geologic and well characteristics. Most wells in the St. Louis area yield a maximum of 50 gallons per minute from depths down to 800 ft bgs. These wells are screened in limestones and sandstones ranging in age from Mississippian to Ordovician. Water yields of up to 1,955 gallons per minutes (gpm) can be expected from the wells drilled in thick alluvial deposits that contain little silt or clay-like material (URS, 2002). However, no potable water wells are reported to exist within 3 miles down gradient of SLAAP (USAEHA, 1993). While MDNR indicated during the Data Summary Meeting of May 24, 2004 that drilling of drinking water wells in the City of St. Louis is prohibited, USACE-KCD was not able to confirm

this to be true. MDNR's Wellhead Protection Section provided documentation that an ordinance once existed, but was later repealed.

#### **4.6 CLIMATOLOGY**

The climate in St. Louis County is characteristic of temperate continental, with warm-to-hot summers and cool winters. The heaviest rains occur in spring and early summer, when moist air from the Gulf of Mexico interacts with drier continental air (Soil Conservation Service, 1979). The daily temperature for the St. Louis area averages about 55 degrees Fahrenheit (°F). The temperature averages about 33°F in winter, and about 77°F in the summer. The growing season for most crops extends from April to September.

Total annual precipitation is 33.8 inches, with the greatest amount falling in June. Average seasonal snowfall for the region is 18 inches, with most accumulation occurring in March. Wind prevails from the south with the highest wind speed averaging 12 miles per hour in March.

#### **4.7 ECOLOGY**

The former SLOP site does not provide suitable habitat to sustain an ecological community. Except for small grassy areas, buildings, asphalt and concrete cover the property. The closest body of water, the Mississippi River, is located about 3 miles from the property. According to the URS (July 2002) work plan for the adjacent SLAAP site, no endangered species were identified in the vicinity. Additionally, the URS work plan indicates that the Missouri Department of Conservation stated in a 1993 letter that no impact to endangered species or sensitive environmental concerns are expected in this vicinity.

\* \* \*

## 5.0 DATA EVALUATION

This section presents an evaluation of the environmental data from all sampling events, including historical and the latest Phase I RI. For the Phase I, all samples were analyzed by the methods noted in the work plan and the data was evaluated using the guidance noted in the quality assurance project plan. **Appendix F** presents the Data Quality Summary for the sample collected during the Phase I RI fieldwork and **Appendix G** presents the positive hits tables from all sampling events. The following section explains the risk-based screening criteria and background levels that were utilized in the evaluation.

### 5.1 SCREENING CRITERIA

#### 5.1.1 Soil/Sediment Screening Criteria

Health-based screening criteria selected for evaluating soils and sediment data were USEPA Region 9 Preliminary Remediation Goals (PRGs) established for residential, industrial, and leaching to groundwater protection. These criteria are shown in **Table 5-1** and reflect the most recent numbers posted to the Region 9 website in the latter part of October 2004. As a result of this update, screening results presented herein may vary slightly from the presentation of historical data in the work plan.

As noted in the work plan, MDNR publishes risk-based screening criteria in *Cleanup Levels for Missouri (CALM)* (MDNR, 2001). These numbers are calculated in a similar manner as the USEPA Region 9 PRGs described; however, CALM values are not updated as frequently. For this reason, PRGs were the basis for the data evaluation in the work plan and in this technical memorandum, with one exception. The one exception is arsenic. MDNR CALM Tier 1 values take into account the fact that background levels of arsenic in soil exceed the calculated risk-based concentrations. Therefore, CALM Tier 1 values for arsenic are substituted for the USEPA Region 9 residential and industrial PRG values.

One of the objectives of the Phase I RI work plan was to collect geotechnical information so that site-specific leaching to groundwater protection numbers could be generated. The data are presented in **Appendix H** and show that the soil type across the site is consistently a silty loam. This is the soil type assumed by USEPA in selecting default parameter values for calculating the leaching protection criteria. Therefore, site-specific values were not generated since they would in essence be the same as those published. However, it is important to consider the conservative nature of the soil to groundwater screening criteria that are applied in this evaluation. The USEPA guidance (1996) stresses the simplifying assumptions of the equation, which include: 1) an infinite and uniform source in the soil; 2) no attenuation in soil; 3) instantaneous and linear partitioning equilibrium between soil and groundwater; 4) an unconfined, unconsolidated aquifer with homogenous and isotropic hydrologic properties; and 5) a receptor well at the source, thus no attenuation in the aquifer. Not all, and often few, of these listed conditions are actually met at hazardous waste sites. Studies have shown that the longer contamination is adsorbed to soil particles, the slower it is to partition from soil to water and, in fact, may never reach equilibrium between soil and groundwater (Lyman, 1996).

Surface soil background levels were determined for select metals and PAHs, since risk-based screening criteria for these constituents can be at levels less than site background. The selected metals and PAHs included antimony, arsenic, selenium, thallium, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. Note that only surface soil background was determined because anthropogenic PAHs are usually the result of atmospheric deposition on the ground surface. Since most sediment originate at the surface, the surface soil background levels were also applied to sediment.

The background concentrations were determined following methods from USEPA background guidance documents (1989, 1992, 1995, and 2002) and from publications by A. Singh, et al. (1994 and 1997). As with any environmental site, the dataset likely includes samples collected from unimpacted areas that represent background, as well as samples from the areas of suspected contamination. A statistical technique developed by Singh, et al., (1994) separates the lower-end distribution of the dataset, which represents background, from other distributions in the dataset. After iterations to remove outliers, a "robustified" upper tolerance limit (UTL) of the lower-end distribution is then identified as the concentration representing background (Singh, et al., 1997). According to the definition of a UTL, in this case a 95% UTL, the reviewer can be 95 percent confident that 95 percent of the background data fall below this upper tolerance limit (USEPA, 2002). Thus, it is worth noting that by definition there is a possibility that some concentrations may be above the UTL level and yet be part of the background distribution.

A summary of the background statistical information for select chemicals in surface soil is presented in **Table 5-2. Appendix I** provides plotted distributions (i.e., probability plots) for each dataset, before and after the background UTL was determined. The "before" plots are provided to visually demonstrate the point that more than one population is present (e.g., at a minimum, background data which plots near zero, and data which represents contamination). The "after" plots are probability plots of only the data points less than the robustified UTL. These are provided to show that the background dataset is normal and/or lognormal. If the background dataset is both normal and lognormal, the distribution with the highest correlation coefficient was determined to be background.

Of the background levels determined, those for arsenic, selenium, and the PAHs were greater than the lowest risk-based screening criteria. For these constituents, only surface soil and sediment sampling results that are above both background and risk-based screening criteria are discussed in the soil/sediment evaluation section.

### **5.1.2 Groundwater/Surface Water Screening Criteria**

For surface water (i.e., water found in sewers, tunnels, or powder wells) and for groundwater, the Region 9 PRGs for tap water protection and the federal maximum contaminant levels (MCLs) were used for evaluation purposes. Published surface water criteria are established for various beneficial uses, such as fisheries or full-body recreational contact. The waters found on the site do not qualify for beneficial uses, nor are there completed exposure pathways such as ingestion or dermal contact. However, if an exposure pathway were to become complete, it would likely



begin with migration into groundwater. Therefore, groundwater screening criteria were used for the "surface" water located on the site. Criteria are shown in **Table 5-1**.

## **5.2 SEDIMENT/WATER DATA EVALUATION**

No new sediment and associated water data were collected from powder wells, sewer lines, or tunnels during the Phase I RI fieldwork. However, the historical data were screened again for this evaluation with the updated PRGs and the results are shown in **Figure 5-1**. Chemicals found in these potential "source areas" provide a focus on the types of contaminants related to historical activities at the site.

### **5.2.1 Analyses and Results**

**Table 5-3** provides a summary of analyses and results for sediment and associated water samples. Positive hits tables are provided in **Appendix G**.

During previous site investigations, sediment samples were collected from powder wells, sewer lines, and tunnels (refer to **Figure 5.1**). Most of the dataset consisted of samples collected from 19 of the powder wells. Powder wells not sampled included PWs 4, 5, 6, and 7, i.e., four of the eight associated with the 227 building series. Tunnel samples were collected at seven locations and sewer samples were collected at five locations. One of the sewer sampling locations was considered upgradient of the site, SED-SEW-UPG. Although the sampling locations were located downgradient from PW25, note that none of the detections in PW25 exceeded screening criteria.

Of the sediment samples collected, 34 were analyzed for metals, with an additional three (for a total of 37) analyzed for lead. There were a total of 28 (9 tunnel and 19 powder well sediment samples) collected for explosives analyses. Four samples were collected for VOCs analyses, all from sewer lines. SVOCs and PCBs analyses were not performed on any of the sediment samples.

Water from sewer lines and tunnels was sampled during previous investigations and analyzed for metals in seven of the samples, explosives in eight of the samples, and VOCs in six of the samples. Analysis for SVOCs and PCBs were not performed on the surface water samples.

In general, metals were detected in all the sediment and surface water samples. Explosives were detected in 17 of 19 powder well sediment samples. Only one explosive, 4-nitrotoluene, was detected in sediment other than sediment collected from powder wells; it was found in tunnel sediment sample, SED-218A. Explosives were not detected in the surface water samples. VOCs were not detected in any of the sediment samples, but chloroform was detected in two surface water samples, SW-SEW2 and SW-SEW3.

### **5.2.2 Chemicals Above Criteria**

**Table 5-4** is a list of chemicals that exceeded screening criteria in sediment or associated water samples.

Metals detected in sediment samples at concentrations above screening criteria included the following: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, selenium, thallium, and zinc. Of the metals detected above screening criteria in 26 samples, lead exceeded the criteria most often (in every sample), followed by cadmium and iron (in 17 samples each), chromium (in 15 samples), arsenic (in 12 samples), selenium (in 8 samples), and antimony and thallium (in six samples each). The remaining metals exceeded criteria in five or less of the sediment samples.

Three explosives were detected in powder well sediment samples at concentrations above screening criteria. These included 2,6-dinitrotoluene in 8 powder wells (8, 12, 15, 16, 20, 21, and 22), 2,4-dinitrotoluene only in powder well 19, and nitrobenzene only in powder well 16). The one explosive detected in a tunnel sediment sample, 4-nitrotoluene, was below screening criteria.

Water detections above screening criteria consisted of lead, antimony, cadmium, and chloroform. All metals exceeded their respective MCLs and PRGs, except for cadmium, which only exceeded its MCL. Chloroform exceeded its PRG in two water samples.

### **5.2.3 Chemical Distribution in Sediment**

#### **Powder Wells**

Sediment data collected from powder wells indicate several metals with elevated concentrations, but few explosives. Lead is the most widespread of the metals, as is 2,6-DNT for the explosives. The highest levels of lead are found in powder wells associated with building 218 series, the maximum concentration was 25,387 mg/kg in PW17. All but one of the powder wells with explosives are associated with the building 218 series.

Powder well PW8, with elevated 2,6-DNT (0.186 J mg/kg), is associated with the 227 building series; however, PW9 also associated with the 227 series, was nondetect for explosives. Lead measured 3,732 and 1,075 mg/kg, in PW8 and PW9, respectively.

Powder wells PW1 and PW2, associated with the 228 buildings had lead levels of 419 and 637 mg/kg, respectively. Arsenic detected in PW2 is likely at a level (13.6 mg/kg) within the background distribution.

#### **Tunnels**

Metals were elevated above screening criteria in tunnel samples. The highest detections of arsenic in sediment were seen in SED-TUN3 (49.2 J mg/kg) and in SED-TUN6 (40 J mg/kg).

#### **Sewers**

Sediment data from sewers show some metals at concentrations greater than screening criteria.

Water samples collected from tunnels show antimony, cadmium, and lead at elevated concentrations. Water samples taken in sewer lines show only elevated lead, with the highest

detection from any of the sewer samples found in sample SED-SEW-UPG, considered as an upgradient or background sample.

### 5.3 SOILS DATA EVALUATION

For this technical memorandum, soil sampling locations from previous work and from this Phase I RI sampling event were compiled onto one figure to provide a more visual presentation of vertical and horizontal extent of chemicals that exceeded screening criteria. **Figure 5-2** shows the soil samples with chemical exceedances, sampling depth where exceedances occurred, and the specific criteria that were exceeded. Note that some surface soil samples collected during the 2001 investigation for metals analysis were composite samples, and again in 2005, for both metals and PAH analyses. These are distinguished in the legend from the discrete surface soil locations.

#### 5.3.1 Analyses and Results

**Table 5-5** provides a summary of analyses and results for all soils data. Positive hits tables are provided in **Appendix G**.

#### 5.3.2 Chemicals Above Criteria

**Table 5-6** is a list of chemicals that exceeded screening criteria in any of the soil samples. It shows sample location and depth, as well as an indication of which screening criteria were exceeded.

##### Metals

In 109 soil samples collected from 0 to 1 ft-bgs and analyzed for metals by various analytical techniques, the following metals exceeded at least one screening criteria: antimony; arsenic; lead; selenium; silver; and thallium.

- Antimony was seen above screening criteria in four soil samples, with the highest detection near building 227O. All exceedances were in surface soil. Antimony failed leaching potential screening criteria only, and was not elevated in any of the samples taken at depth.
- Arsenic detections above screening criteria ranged from 13.6 J to 108 mg/kg. The highest levels were seen in surface soil near buildings 219B and 219C. Except for arsenic near buildings 219E and 219F, all detections of arsenic in exceedance are only slightly above the background concentration (12.5 mg/kg) and may still be part of the background distribution.
- Lead failed screening criteria in eight surface soil samples, ranging from 445 mg/kg in composite sample SS-218C-2 to 2,724 mg/kg in composite sample SS-218A-2.
- Selenium was detected above screening criteria in only three soil samples collected at the surface. While selenium only failed for leaching potential, it was not elevated in any samples taken at depth.

- Silver was detected above its screening criteria for leaching potential in one soil sample, NS05B (1-2 ft-bgs) at a concentration of 82.6 mg/kg. Detected at low levels (< 0.1 mg/kg) in nine subsurface soils, none of these detections fail screening.
- Thallium exceeded the Res-PRG in composite surface soil samples collected east and west of building 218A and in the composite surface soil sample collected east of building 218B. Thallium did not exceed criteria at any other depth.

Of the 22 soil samples collected from 1 to 2 ft-bgs and analyzed for various metals, only three samples had metals detected above screening criteria. Arsenic at 16.7 mg/kg exceeded its Res-PRG in sample NS08B; chromium at 57.7 mg/kg in sample SS44B exceeded its screening criteria for leaching to groundwater protection; and silver at 82.6 mg/kg in sample NS05B also exceeded its screening criteria for leaching criteria.

There were no metal exceedances in the 19 soil samples collected from 3 to 6 ft-bgs.

In the 11 soil samples collected from 6 to 9 ft-bgs for metals analysis, iron exceeded the Res-PRG in one sample (23,197 mg/kg in SLOP-SB-020).

In the five samples collected from 9 to 12 ft-bgs for metals analysis, iron exceeded the Res-PRG in one sample (26,292 mg/kg in SLOP-SB-007).

There were no metals exceeding criteria in the five samples collected from 12 to 20 ft-bgs.

In the five samples collected from 20 to 29 ft bgs, only arsenic exceeded the Res-PRG in one sample (15.8 mg/kg in SUB-SEW3).

#### PAHs

There were 9 composite and 26 discrete surface soil samples collected from 0 to 1 ft-bgs for PAH analysis, with exceedances of criteria occurring in only two discrete samples. Six PAHs were detected in SLOP-SB-020, all at concentrations above their respective risk-based screening criteria. Benzo(a)anthracene in SLOP-SB-010 exceeded its Res-PRG with a measured concentration of 0.73 mg/kg.

There were 20 soil samples collected from 1-2 ft-bgs for PAH analysis. Benzo(a)pyrene exceeded the Res-PRG in samples NS02B, NS03B, NS05B, and NS07B. Indeno(1,2,3-cd)pyrene exceeded its Res-PRG in NS02B.

There were 13 soil samples collected from 3 to 4 ft-bgs for PAH analysis. Three samples (SLOP-SB002, SLOP-SB017, and SLOP-SB019) had detections of benzo(a)pyrene above its Res-PRG value (0.121, 0.131, and 0.119, respectively).

One soil sample was collected from 7 to 8 ft-bgs for PAH analysis. None of the PAHs detected exceeded screening criteria.

### Explosives

There were 56 soil samples collected at the surface (0 to 1 ft-bgs) for explosives analysis. Explosives were not detected in any of the samples.

A total of 13 soil samples were collected from 1 to 2 ft-bgs and analyzed for explosives; explosives were nondetect.

Two samples were collected from 3 to 4 ft-bgs for explosives analysis; both samples were nondetect.

Ten samples were collected from 6 to 9 ft-bgs for explosives analysis; all were nondetect.

Five samples were collected from 9 to 12 ft-bgs for explosives analysis; all were nondetect.

Five samples were collected from 12 to 20 ft-bgs for explosives analysis; all were nondetect.

Five samples were collected from 20 to 29 ft-bgs for explosives and none had detections.

### VOCs

Eight soil samples were collected from 0 to 1 ft-bgs for VOCs analysis; all were nondetect.

Fourteen samples were collected from 1 to 2 ft-bgs for VOCs analysis; all were nondetect.

Five samples were collected from 3 to 6 ft-bgs for VOCs analysis. Carbon tetrachloride was detected in SLOP-SB-014 at 0.00428 J mg/kg, well below screening criteria. There was one detection of m-, p-xylenes in SLOP-SB-002, but the concentration of 0.00263 J mg/kg was well below screening criteria.

Eight soil samples were collected from 6 to 9 ft-bgs for VOCs analysis; all were nondetect.

Six soil samples were collected from 9 to 12 ft-bgs for VOCs analysis; all were nondetect.

Four soil samples were collected from 12 to 20 ft-bgs for VOCs analysis; all were nondetect.

Of the five soil samples collected from 20 to 29 ft bgs for VOCs analysis, sample SLOP-SB-016 had a detection of carbon tetrachloride, which was well below screening criteria.

### PCBs

Four surface soil samples were collected for PCBs analysis near the former transformer located at building 228C. Three of the four samples failed screening criteria with Aroclor 1260 ranging from 13.6 to 569 mg/kg. The detected concentrations exceeded Res-PRG and Ind-PRG levels, but not the screening level for protection of groundwater.

### 5.3.3 Chemical Distribution

The data indicates that elevated metals are a potential problem only in the surface and near surface soils. Soil borings show that where metals exceed the leaching protection criteria in an upper interval, exceedances for that metal are not occurring at a depth. The four exceedances that do occur at a depth other than 0-1 ft-bgs, occur from 1 to 2 ft bgs. The chemicals in exceedance at this interval are arsenic, chromium, silver, and indeno(1,2,3-cd)pyrene, with one exceedance of each.

The areas with the highest levels of arsenic in surface soil are near buildings 219B and 219C. The highest detection of lead in soil is located north of building 218A and to the south of the 228W-Z buildings. Thallium exceedances may possibly be within the background distribution and all exceedances are J coded (meaning an estimated value). The areas with thallium exceedances are north and south of building 218A and south of building 218B.

Two surface soil samples had PAHs in exceedance of screening criteria; these were located north of building 220 and south of building 219G. Five shallow soil samples collected from 1-2 ft-bgs had exceedances for benzo(a)pyrene; one of these samples (south of building 219J) included an exceedance of indeno(1,2,3-cd) pyrene. Benzo(a)pyrene was also above its Res-PRG in three samples collected from 3-4 ft-bgs.

PCBs were elevated in the former transformer area, which is located south of building 228C.

Explosives were nondetect in all the soils samples collected at the site. Two soil samples had one VOC each detected, both VOCs detected (carbon tetrachloride and m-, p-xylenes) were J coded, and both were below screening criteria.

## 5.4 GROUNDWATER DATA EVALUATION

Figure 5-3 shows the monitoring wells and the direct push sampling locations, highlighting the locations with chemicals in exceedance of screening criteria, i.e., MCLs or tap water PRGs.

Analytical results are available from six monitoring wells, with two rounds of data collected in 2001 and in 2005 for MW101 through MW105. Monitoring well MW106 was installed during the Phase I RI fieldwork; therefore, there is only one round of data available from this well.

### 5.4.1 Analyses and Results

Table 5-8 provides a summary of analytical results for the direct push groundwater samples that were collected in 2001. Table 5-9 provides a summary of analyses and results for all monitoring well sampling events. This includes two rounds of data collected in 2001 and 2005 for MW101 through MW105. Monitoring well MW106 was installed during the Phase I RI fieldwork; therefore, there is only one round of data available from this well. Metals, explosives, and VOCs were the target analytes in samples taken in 2001 and 2005. Positive hits tables are provided in Appendix G.

Note that the direct push samples that exceed screening criteria for organics are located to the south of the site and are considered upgradient (i.e., those direct push samples surrounding GW-MW103) or considered side gradient (i.e., GW-DP3).

Metals detected in monitoring well samples included aluminum, arsenic, barium, chromium, cobalt, iron, manganese, nickel, selenium, and zinc. Note that this evaluation did not consider the direct push groundwater sampling results for metals because of the high turbidity and thus the possibility that elevated concentrations are due to soil particulates in the water samples.

The following VOCs were detected: 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene; acetone; carbon disulfide; carbon tetrachloride; 1,2-dichloroethane (DCA); cis-1,2-DCE; trans-1,2-DCE; and vinyl chloride. The chlorinated solvents were only detected in the upgradient monitoring well MW101, or in a direct push sample taken near MW101. Carbon disulfide and DCA were detected in the side gradient, direct push sample GW-DP3 taken in 2001. 1,2,4-Trimethylbenzene and 1,3,5-trimethylbenzene were detected in direct push sample GW-DP2. Carbon tetrachloride was detected in MW105, only in 2001. DCA was detected in monitoring wells MW105 and MW106 in 2005.

Explosives were not detected in any of the monitoring well samples, but 3-nitrotoluene was detected at low concentrations GW-DP4 and GW-DP11; both hits were qualified as estimated.

#### **5.4.2 Chemicals Above Criteria**

Table 5-10 is a list of chemicals that exceeded screening criteria in groundwater samples.

MCLs were exceeded for two chemicals, thallium in MW103 and cis-1,2-DCE, in the upgradient well, MW101.

Metals exceeding tap water PRGs included: arsenic in three monitoring wells, iron in two monitoring wells, manganese in four monitoring wells, and thallium in one.

Cis-1,2-DCE and vinyl chloride exceeded their respective PRGs in the upgradient well. Carbon tetrachloride exceeded its respective PRG in MW105 during the 2001 sampling event, but not in 2005. DCA exceeded its respective PRG in MW105 and MW106 during the 2005 sampling event.

The explosive 3-nitrotoluene, detected in the two direct push samples, was below screening criteria.

#### **5.4.3 Chemical Distribution**

Chlorinated solvents were detected south of the site, in monitoring well MW101, which is considered upgradient of the site. Carbon tetrachloride and DCA were detected north of the site in two monitoring wells considered downgradient; these wells are located east of buildings 219A and 220. Metals were in exceedance in the upgradient sample and in samples collected near

buildings 228M, 218C, and to direct to the east of the site. The maximum detection of arsenic was seen in the upgradient monitoring well; the second highest detection was seen in MW103 during the 2005 sampling event. Arsenic was detected in some of the soil and sediment samples above its screening criteria for groundwater protection; other metals seen above criteria in groundwater do not have soil screening criteria for groundwater protection.

\* \* \*



Carbon tetrachloride and DCA were detected north and downgradient of the site in two monitoring wells, MW105 and MW106. These wells are located east of building 219A and 220. No monitoring wells exist in the northwestern boundary of the site, which is upgradient of MW105 and MW106. The two contaminants, carbon tetrachloride and DCA, are isolated to these wells and have not been delineated. Note that carbon tetrachloride was not detected in the 2005 monitoring well sampling event. In the several soil borings placed in proximity of these wells, only two VOC detections were found in soil. Both detections were of carbon tetrachloride and both were below soil screening criteria. Soils data in this vicinity does not appear to represent a contaminant source to groundwater and at best only seem to indicate a residual or depleted source.

While 3-nitrotoluene was detected in two direct push samples, neither of the qualified detections exceeded screening criteria.

Metals were in exceedance of their respective screening criteria in the upgradient groundwater sample and in samples collected near buildings 228M, 218C, and directly east of the site. The highest detection of arsenic in groundwater was seen in the upgradient well, with the second highest detection seen in MW103. The detection of arsenic in MW103 was approximately ten times greater during the 2005 sampling event than in 2001. Arsenic was detected in some of the soil and sediment samples at concentrations above its screening criteria for groundwater protection. However, the highest detections of arsenic in solid media were not located upgradient of MW103. Other metals seen above groundwater criteria do not have soil screening criteria established for groundwater protection. (Please see **Figures 5-2 and 5-3** for data illustrations.)

\* \* \*

## 6.0 CONTAMINANT SUMMARY

### 6.1 SEDIMENT/WATER

Tunnel sediments have been subsequently removed during building demolition, thereby likely eliminating any potential sources of contamination to tunnel water.

Explosives were detected in 17 of the 19 powder well sediment samples, and explosives in nine of the powder well samples were above screening criteria. Metals were detected above screening criteria in most of the powder wells sampled.

Sediment samples from sewer lines show only lead above screening criteria; however, lead was also above screening criteria in SED-SEW-UPG, which is considered upgradient of the site. Explosives were nondetect in all the sewer samples taken.

Water samples taken in sewer lines show only elevated lead, with the highest detection from any of the sewer samples found in SED-DEW-UPG, consider an upgradient, background sample. Chloroform was detected in two of the sewer water samples.

Based on this information, no data gaps were identified for sediment or water in powder wells and sewer lines. (Please see **Figure 5-1** for data illustration.)

### 6.2 SOIL

There is an area of localized PCB contamination near building 228C. Metals contamination is localized and limited to surface and near surface soil. Three surface soil samples with PAHs exceedances also indicate localized problems. Benzo(a)pyrene exceedances occurred in five samples from 1-2 ft-bgs and in three samples from 3-4 ft-bgs.

With the exception of iron above screening criteria in two samples at 8-9 ft-bgs and 11-12 ft-bgs, and arsenic at 20-21 ft-bgs in one sample, deep soil is not impacted. Explosives were nondetect in soil.

Based on the plotted data there were no data gaps identified. (Please see **Figure 5-2** for data illustration.)

### 6.3 GROUNDWATER

Chlorinated solvents were detected, south and upgradient of the site, in monitoring well MW101 and in direct push samples surrounding MW101.

Carbon disulfide and DCA were detected in the direct push sample GW-DP3, located to the south and side gradient of the site.

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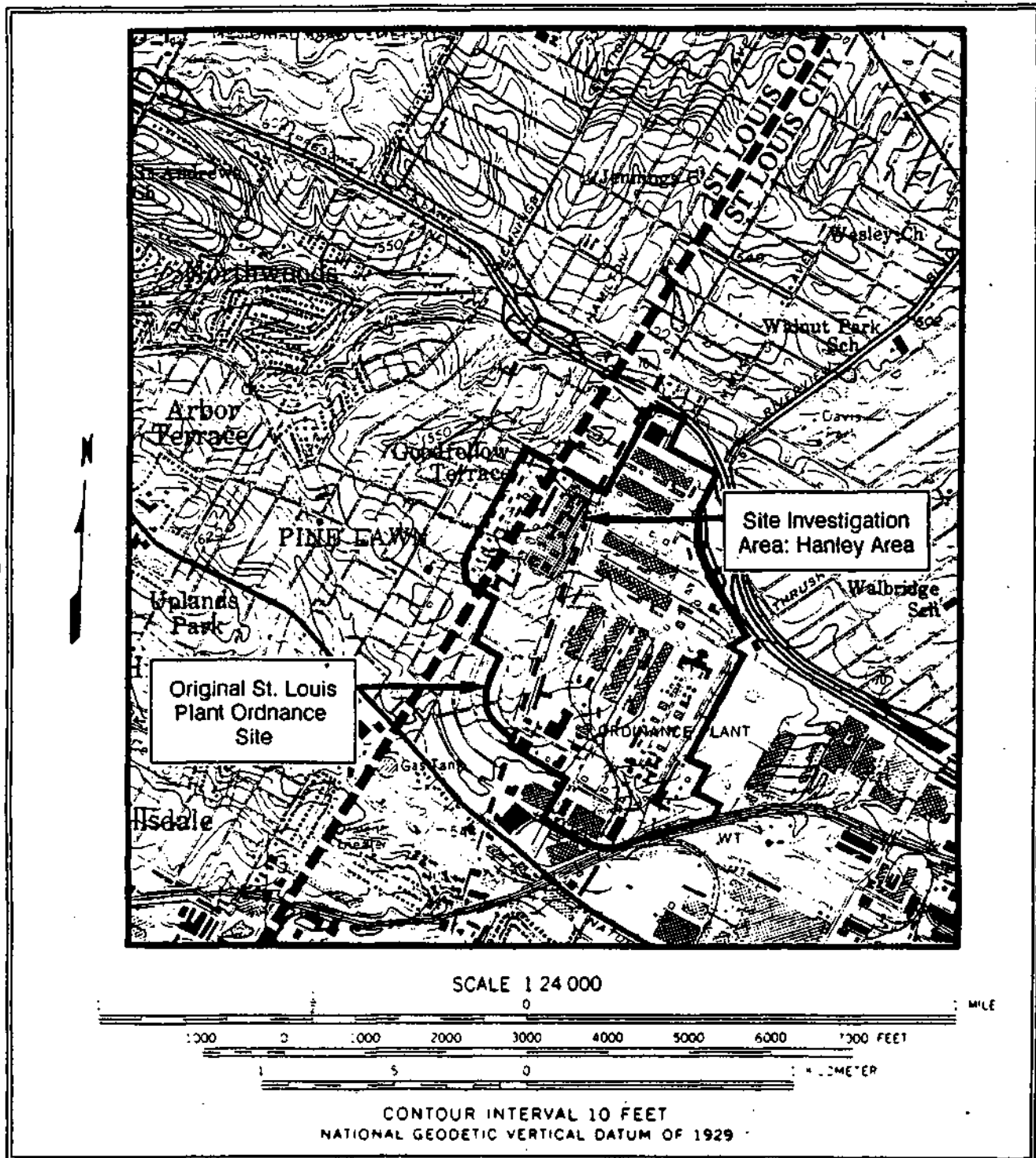
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\* \* \*

**FIGURES**

Figure 1-1  
General Site Map



**Table 3-1**  
**Soil Sample Identification Numbers, Depths and Analyses**

Sample Type	Sample Identifier	Sample Depth	Soil Analytes									
			VOC SW-8035/8260B	PAH SW-8270C (SIM)	TAL Metals SW-6010B/6020A/7000	Explosives SW-8330	PCBs SW-8032	TOC SW-9160	Soil pH SW-9045C	Moisture Content ASTM D2216	Sieve Analysis ASTM D422	Bulk Density ASTM D2937
			(3) 40-ml vials	4oz cwn	4oz cwn	4oz wvn Amber	4oz cwn	4oz wvn Amber	4oz cwn	4oz cwn or Shelby Tube	gallon ziplock or Shelby Tube	Shelby Tube
			PC	PC	None	PC	PC	PC	PC	None	None	None
Discrete Soil Samples												
Surface	SLOP-SB-001	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-001	3 to 4		F	F							
Sewer	SLOP-SB-001	5 to 6	F		F	F						
Geotechnical	SLOP-SB-001	5 to 8								F	F	
Geotechnical	SLOP-SB-001	15 to 18								F	F	
Surface	SLOP-SB-002	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-002	3 to 4		F	F							
Sewer	SLOP-SB-002	5 to 6	F,MS,MSD		F	F						
Surface	SLOP-SB-003	0 to 1		F	F							
Powder Well	SLOP-SB-003	5 to 6	F		F	F						
Surface	SLOP-SB-004	0 to 1		NS	NS							
	SLOP-SB-004	0.5 to 1						NS	NS			
Powder Well	SLOP-SB-004	6 to 7	NS		NS	NS						
	SLOP-SB-004	11 to 11.5						NS	NS			
Surface	SLOP-SB-005	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-005	3 to 4		F	F							
Powder Well	SLOP-SB-005	6 to 7	F		F, MS, MSD	F, MS, MSD						
Shallow Subsurface	SLOP-SB-006	1 to 2		F	F							
Shallow Subsurface	SLOP-SB-006	7 to 8		F	F							
Foundation	SLOP-SB-006	11 to 12	F		F	F						
Foundation	SLOP-SB-007	11 to 12	F		F	F						
Surface	SLOP-SB-008	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-008	3 to 4		F, QA, QC	F, QA, QC							
Foundation	SLOP-SB-008	11 to 12	F		F	F						
Surface	SLOP-SB-009	0 to 1		F	F							

**Table 3-1**  
**Soil Sample Identification Numbers, Depths and Analyses**

Sample Type	Sample Identifier	Sample Depth	Soil Analytes									
			VOCs SW-5035/8260B	PAHs SW-8270C (SIM)	TAL Metals SW-6010B/6020A/7000	Explosives SW-8330	PCBs SW-8082	TOC SW-9060	Soil pH SW-9045B	Moisture Content ASTM D2216	Sieve Analysis ASTM D422	Bulk Density ASTM D2937
			(3) 40-ml vials	4 oz. cwm	4 oz. cwm	4 oz. w/m Amber	4oz. cwm	4 oz. w/m Amber	4 oz. cwm	4 oz. cwm or Shelby tube	gallon ziplock or Shelby tube	Shelby tube
			4°C	4°C	None	4°C	PC	4°C	4°C	None	None	None
Shallow Subsurface	SLOP-SB-009	3 to 4		F	F							
Geotechnical	SLOP-SB-009	5 to 8							F	F		
Sewer	SLOP-SB-009	19 to 20	F		F	F						
Surface	SLOP-SB-010	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-010	3 to 4		F	F							
Sewer	SLOP-SB-010	8 to 9	F		F	F						
Sewer	SLOP-SB-010	19 to 20	F		F	F						
Surface	SLOP-SB-011	0 to 1		F	F							
Shallow Subsurface/Sewer	SLOP-SB-011	3 to 4	F	F	F	F						
Surface	SLOP-SB-012	0 to 1		F	F							
	SLOP-SB-012	0.5 to 1						F	F			
Powder Well	SLOP-SB-012	6 to 7	F, QA, QC		F, QA, QC	F, QA, QC						
	SLOP-SB-012	11 to 11.5						F	F			
Surface	SLOP-SB-013	0 to 1		F	F							
Sewer	SLOP-SB-013	6 to 7	F		F	F						
Surface	SLOP-SB-014	0 to 1		F, QA, QC	F, QA, QC							
Shallow Subsurface	SLOP-SB-014	3 to 4		F	F	F						
Powder Well/Sewer	SLOP-SB-014	6 to 7	F		F	F						
Surface	SLOP-SB-015	0 to 1		F	F							
Powder Well	SLOP-SB-015	6 to 7	F		F	F						
Surface	SLOP-SB-016	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-016	3 to 4		F, MS, MSD	F, MS, MSD							
Sewer	SLOP-SB-016	10 to 11	F		F	F						
Geotechnical	SLOP-SB-016	15 to 18							F	F		
Sewer	SLOP-SB-016	22 to 23	F		F	F						



**Table 3-1**  
**Soil Sample Identification Numbers, Depths and Analyses**

Sample Type	Sample Identifier	Sample Depth	Soil Analytes									
			VOC SW-5035/8260B	PAHs SW-8270C (SIM)	TAL Metals SW-6010B/6020A/7000	Explosives SW-8330	PCBs SW-8082	TOC SW-9060	Soil pH SW-9045C	Moisture Content ASTM D2216	Sieve Analysis ASTM D422	Bulk Density ASTM D2937
			(3) 40-ml vials	4oz cwn	4oz cwn	4oz wv Amber	4oz cwn	4oz wv Amber	4oz cwn	4oz cwn or Shelby Tube	galton ziplock or Shelby Tube	Shelby Tube
			PC	PC	None	PC	PC	PC	PC	None	None	None
Surface	SLOP-SB-017	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-017	3 to 4		F	F							
Foundation	SLOP-SB-017	11 to 12	F		F	F						
Surface	SLOP-SB-018	0 to 1		F	F							
Powder Well	SLOP-SB-018	0.5 to 1						F	F			
	SLOP-SB-018	6 to 7	F		F	F						
	SLOP-SB-018	11 to 11.5						F	F			
Surface	SLOP-SB-019	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-019	3 to 4		F	F							
Sewer	SLOP-SB-019	22 to 23	F		F	F						
Surface	SLOP-SB-020	0 to 1		F	F							
Shallow Subsurface	SLOP-SB-020	3 to 4		F	F							
Sewer	SLOP-SB-020	8 to 9	F, QA, QC		F, QA, QC	F, QA, QC						
Sewer	SLOP-SB-021	15 to 16	F		F	F						
Sewer	SLOP-SB-022	15 to 16	F		F	F						
Monitoring Well	SLOP-SB-023	0.5 to 2.5								F	F	F
Monitoring Well	SLOP-SB-023	16 to 18								F	F	F
Discrete Surface Soil Samples												
Surface	SLOP-SS-001	0 to 1					F, QA, QC					
Surface	SLOP-SS-002	0 to 1					F					
Composite Surface Soil Samples												
Surface	SLOP-CSS-001	0 to 1			F							
Surface	SLOP-CSS-002	0 to 1			F							
Surface	SLOP-CSS-003	0 to 1			F							
Surface	SLOP-CSS-004	0 to 1			F							
Surface	SLOP-CSS-005	0 to 1		F	F							

**Table 3-1**  
**Soil Sample Identification Numbers, Depths and Analyses**

Sample Type	Sample Identifier	Sample Depth	Soil Analytes									
			VOC SW-5035/8260B	PAHs SW-8270C (SIM)	ATL Metals SW-6010B/6020A/7000	Explosives SW-8330	PCBs SW-8082	TOC SW-9060	Soil pH SW-9045C	Moisture Content ASTM D2216	Sieve Analysis ASTM D422	Bulk Density ASTM D2937
			(3) 40-mL vials	4 oz. cwm	4 oz. cwm	4 oz. w/m Amber	4 oz. cwm	4 oz. w/m Amber	4 oz. cwm	4 oz. cwm or Shelby Tube	gallon, ziplock or Shelby Tube	Shelby Tube
			4°C	4°C	None	4°C	4°C	4°C	4°C	None	None	None
Surface	SLOP-CSS-006	0 to 1		F	F							
Surface	SLOP-CSS-007	0 to 1		F, MS, MSD	F, MS, MSD							
Surface	SLOP-CSS-008	0 to 1		F	F							
Surface	SLOP-CSS-009	0 to 1		F	F							
Surface	SLOP-CSS-010	0 to 1		F	F							
Surface	SLOP-CSS-011	0 to 1		F, QA, QC	F, QA, QC							
Surface	SLOP-CSS-012	0 to 1		F	F							
Surface	SLOP-CSS-013	0 to 1		F	F							
Surface	SLOP-CSS-014	0 to 1			F							
Surface	SLOP-CSS-015	0 to 1			F							
<b>Sediment</b>												
Surface	SLOP-SED-001	NA					F					

**Notes:**

F = Field Sample

MS/MSD = Matrix Spike/Matrix Spike Duplicate Sample

QA = Quality Assurance Sample

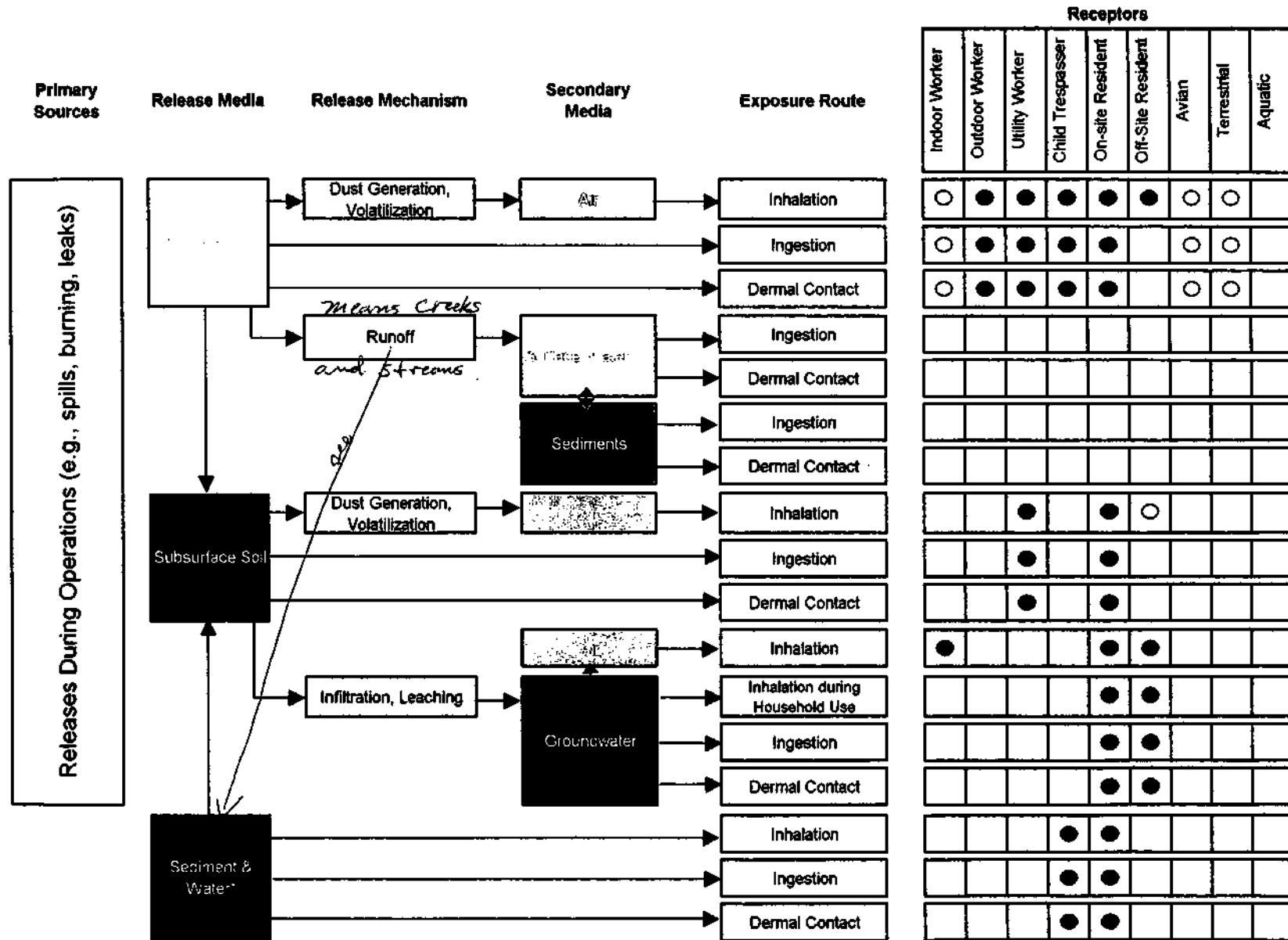
QC = Quality Control Sample

NS = Not Sampled

**Table 3-2**  
**Groundwater Sample Identification Numbers and Analyses**

Sample Type	Sample Identifier	Sample Depth	Groundwater Analyses		
			VOC	Trace Metals	Explosives
			SW-8260B	SW-6010B/6020A/7000	SW-8330
			(3) 40-mL vials	(1) 500-mL poly	(2) 1-L Amber
			HCL to pH<2	HNO <sub>3</sub> to pH<2	4°C
Groundwater Samples					
Groundwater	SLOP-MW-101	NA	F, QA, QC	F, QA, QC	F, QA, QC
Groundwater	SLOP-MW-102	NA	F	F	F
Groundwater	SLOP-MW-103	NA	F, MS, MSD	F, MS, MSD	F, MS, MSD
Groundwater	SLOP-MW-104	NA	F	F	F
Groundwater	SLOP-MW-105	NA	F	F	F
Groundwater	SLOP-MW-106	NA	F	F	F

# Preliminary Conceptual Site Model Former St. Louis Ordnance Plant



Notes: ○ Pathway is considered insignificant.  
● Pathway is potentially complete.

\* Impacted sediment and surface water are located in powder wells, tunnels, and/or sewer lines. Completed exposure pathways are only likely in the tunnels.

## Chemical Exceedances in Sediment

Analysis	Number of Samples	>Res PRG	>Ind PRG	>S-GW
<b>Sewer Sediment</b>				
Metals	4	Lead		
Explosives	3			
VOCs	3			
<b>Tunnel Sediment</b>				
Metals	9	Antimony	Arsenic	Antimony
		Arsenic	Chromium	Arsenic
		Cadmium	Iron	Cadmium
		Chromium	Lead	Chromium
		Copper	Zinc	Selenium
		Iron		Zinc
		Lead		
		Manganese		
		Thallium		
		Zinc		
Explosives	9			
VOCs	9			
<b>Powder Well Sediment</b>				
Metals	19	Arsenic	Chromium	Arsenic
		Barium	Iron	Chromium
		Cadmium	Lead	Zinc
		Chromium	Zinc	
		Copper		
		Iron		
		Lead		
		Manganese		
		Thallium		
		Zinc		
Explosives	19	2,6-DNT	2,6-DNT	2,4-DNT
				2,6-DNT
				Nitrobenzene
VOCs	17			

## Chemical Exceedances in Surface Water

Analysis	Number of Samples	>MCL	> PRG
<b>Sewer Water</b>			
Metals	3	Lead	Lead
Explosives	3		
VOCs	3		Chloroform
<b>Tunnel Water</b>			
Metals	4	Antimony Cadmium Lead	Antimony Lead
Explosives	4		
VOCs	4		

## Chemical Exceedances in Soil

Analysis	Number of Samples	>Res PRG	>Ind PRG	>S-GW
<b>Surface Soil (0-1 ft bgs)</b>				
Metals	109	Arsenic Lead Thallium	Arsenic Lead	Arsenic Antimony Selenium
Explosives	37			
VOCs	24			
SVOCs	35	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene Dibenz(a,h)anthracene	Benzo(a)pyrene Benzo(k)fluoranthene Chrysene Dibenz(a,h)anthracene	Benzo(k)fluoranthene Chrysene Dibenz(a,h)anthracene
PCBs	4	Aroclor 1260	Aroclor 1260	
<b>Soil (1-2 ft bgs)</b>				
Metals	22	Arsenic	Arsenic	Arsenic Chromium Silver
Explosives	14			
VOCs	14			
SVOCs	14	Benzo(a)pyrene Indeno(1,2,3-cd)pyrene	Benzo(a)pyrene	
<b>Soil (3-6 ft bgs)</b>				
Metals	12			
Explosives	5			
VOCs	5			
SVOCs	12	Benzo(a)pyrene		

## Chemical Exceedances in Soil

Analysis	Number of Samples	>Res PRG	>Ind PRG	>S-GW
<b>Soil (6-9 ft bgs)</b>				
Metals	10	Iron		
Explosives	10			
VOCs	10			
<b>Soil (9-12 ft bgs)</b>				
Metals	5	Iron		
Explosives	5			
VOCs	5			
<b>Soil (12-20 ft bgs)</b>				
Metals	5	Iron		
Explosives	4			
VOCs	4			
<b>Soil (20-29 ft bgs)</b>				
Metals	5	Arsenic		
Explosives	5			
VOCs	5			



## Chemical Exceedances in Groundwater

Analysis	Number of Samples	>MCL	> PRG
<b>Direct Push</b>			
Metals	12	Yes	Yes
Explosives	8		3-Nitrotoluene*
VOCs	15		1,2-DCA* Vinyl Chloride*
<b>Monitoring Well</b>			
Metals	11	Thallium	Arsenic Iron Manganese Thallium
Explosives	11		
VOCs	11	cis-1,2-DCE*	1,2-DCA Carbon Tetrachloride cis-1,2-DCE* Vinyl Chloride*

Most all metals exceeded criteria in direct push samples due to turbidity.

\* Organics exceeding criteria only at upgradient or cross-gradient locations.